Blue swimming crab, *Portunus pelagicus* (Linnaeus, 1758) as monitors of mercury contamination from Persian Gulf, South Iran

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Levels of mercury in tissues of blue swimming crab, *Portunus pelagicus* in the Persian Gulf coasts, south Iran were investigated. Hg analysis was performed by Atomic Absorption Spectrophotometer. Distribution pattern of Hg in the tissues of *P. palagicus* was as follows: hepatopancreas > muscle > exoskeleton. Total mercury levels in the tissues of *P. palagicus* from the other six sampling stations ranged between (4.70 ± 0.80 µg/g) and (0.10 ± 0.07 µg/g). In present study recorded that there was negligible differences in Hg levels between *P. pelagicus* sexes. Maximum concentration of the total Hg in all tissues of *P. pelagicus* observes in Bahrekan station (*P*<0.05) during different seasons. There was significant difference (*P*<0.05) between the level of Hg in the tissues of the crab *P. pelagicus*. Differences in Hg levels could have resulted from diverse pollution source, ecological particularity, industries and human activities.

[Keywords: Concentration, Mercury, Blue swimming crab, *Portunus pelagicus*, Persian Gulf]

Introduction

The Persian Gulf is a body of water in the Middle East between the Arabian Peninsula and Iran. This inland sea is connected to the Gulf of Oman by the Strait of Hormuz. Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology, since they are highly persistent and all have the potential to be toxic to living organisms. They are present mainly as suspended colloids or are fixed by organic and mineral substances. Several factors such as size, nature of the environment, seasonal variation and variability in species have been identified as important independent variable influencing metal levels in marine organisms. Depending on physicochemical conditions, the pollutants in dissolved form can later be precipitated.

Common sources of Hg include caustic soda, pulp and paper, and paint manufacturing. Mercury is also used in batteries, dental amalgam, and in bactericides. Hg has as far as we know, no necessary function in any living organism and is considered as a nonessential metal. On the contrary, mercury is among the most toxic elements to man and many higher animals. As for most metals, factors known to influence Hg concentrations and accumulation in the marine organisms include metal bioavailability, season of sampling, hydrodynamics of the environment, size, sex, and changes in tissue composition and reproductive cycle. Accumulation of these metals only begins after the organisms are faced with high concentration in the surrounding medium, but body levels of nonessential metals such as mercury were not found to be regulated by crustacean.

Hg concentrations in aquatic ecosystems are usually monitored by measuring its concentration in water, sediments and biota. Crabs belong to a group of animals known as decapods crustaceans. Most of the marine crabs occurring along the Persian Gulf coasts belong to the family Portunidae. The blue swimming crab, *P. pelagicus* is widely distributed throughout the coastal and estuarine areas of the tropical western Pacific and Indian oceans. *P. pelagicus* is one of the important representatives of decapod crustacean and a species commonly found in Persian Gulf coasts, Iran. Crabs are infrequently reported on in the toxicology literature and metal toxicity data is needed for crustacean from Persian Gulf area. Crabs has the capability of accumulating heavy metals and is thus a suitable bioindicator for environmental contamination with these agents.
hepatopancreas, the key site of heavy metal accumulation in Crustacean, is one of the most important organs that play important roles in metal detoxification. Therefore, it is of great interest to investigate the toxicity of heavy metal on hepatopancreas in *P. pelagicus*. Crabs are an excellent bioindicator of metal contamination and can be used to effectively, and accurately monitor metal level for several reasons.

**Materials and Methods**

The study was carried out in the several adjoining coasts in the Persian Gulf such as Khuzestan Province (including coasts Abadan and Bahrekan), Boushehr Province (including coasts Boushehr and Khark) and Hormozgan Province including coasts Bandar Abbas and Jask (Fig. 1). The Persian Gulf lies on the South Iran, between longitudes 48°25' and 56°25" East, and latitudes 24°30" and 30°30' North. It has an estimated area of 260 km² and extends 600 km offshore to a depth average of about 30-40 m.

Samples of water, surficial sediments and available species of *P. pelagicus* were collected from six coastal localities during two seasons (between Feb and Sept 2011) in Persian Gulf coasts a distance of about 909 km. The six sampling station are shows in Fig. 1. Sampling covered areas of the direct or indirect influence of urban and industrial releases, those located near the mouth of the tributary rivers which carry industrial discharges of pollutants to the offshore waters and a locality not under the influence of industrial or urban releases.

Crabs sampling was performed with shrimp trawl. After sampling, samples were transferred to the laboratory for further analysis. Each crab was properly cleaned by rinsing with distilled water to remove debris, planktons and other external adherent, and then they were dissected for collect tissues hepatopancreas, muscle and exoskeleton. It was then drained under folds of filter, weighed, wrapped in aluminum foil and then frozen at 10 °C prior to analysis. The tissues were placed in clean watch glasses and were oven dried at 105 °C for 1 hour and later cooled in the desiccators. Each sample of crabs was homogenized in an acid-cleaned mortar and 2 g were digested in triplicate in a water bath at 60°C for 6 h after adding 2.5 mL each of concentrated HNO₃ and H₂SO₄.

The analysis of total Hg were done by the cold vapor method, using a Perkin-Elmer Atomic Absorption System AA-2380 with automatic background correction and a Perkin-Elmer Mercury Analysis System 303-0830. Replicate (3 to 5) measurements were made on each sample. All glassware used was cleaned by the procedure described by Ober et al., (1987). All the reagents used were of spectroscopic grade and ultra-high purity (99.9%). In
all experiences several blanks were performed with the reagents used, in order to check for possible contamination. The data obtained were statistically analyzed for confirmation of the results. Metal toxicity from different tissues and sediments was calculated by using regression equation and results were expressed in µg/gm dry weight.

Data were analyzed using the one-way analysis of variance (ANOVA) and group means were compared using Duncans multiple range test. The difference was displayed as statistically significant when $P < 0.05$.

**Results**

Total Hg levels in the tissues of *P. palagicus* from the six sampling stations ranged between $(4.70 \pm 0.80)$ and $(0.19 \pm 0.23 \mu g/g)$ for female crab and between $(4.17 \pm 0.10)$ and $(0.11 \pm 0.34 \mu g/g)$ for male crab. Results of the levels of concentration of Hg in the tissues of the female crab *P. palagicus* are presented in Table 1. In present study, results showed that Hg mean concentration was highest in hepatopancreas, followed by muscle and exoskeleton during different seasons (Figs 2, 3). Highest mean concentration of Hg in the tissues of female crab was found in hepatopancreas $(4.70 \pm 0.80 \mu g/g)$ during Summer season and least mean concentration found in exoskeleton $(0.19 \pm 0.23 \mu g/g)$ during Winter season. Results indicated that Hg mean concentration in hepatopancreas tissue was higher than muscle and exoskeleton. Table 2 showed the Hg mean concentration in the tissues of the male crab *P. palagicus*. Highest mean concentration of Hg in the tissues of male crab was found in hepatopancreas $(4.17 \pm 0.10 \mu g/g)$ during Summer season and least mean concentration found in exoskeleton $(0.11 \pm 0.34 \mu g/g)$ during Winter season. In present study recorded that there was negligible differences in Hg levels between sexes. We found that Hg levels were larger in tissues of female of the s than the males. There were no significant differences in Hg levels between sexes of *P. palagicus*. There was significant difference ($P<0.05$) between the level of Hg in the different stations (Figs 4, 5). The maximum mean concentration of Hg $(4.70 \pm 0.80 \mu g/g)$ was noted in Bahrekan station during Summer season and minimum mean concentration $(0.11 \pm 0.34 \mu g/g)$ was in Boushehr station during Winter season. In the present study, results showed that mean concentrations of Hg in the tissues of crabs in Bahrekan station were significantly higher ($P<0.05$).

![Fig. 2—Mercury levels in tissues of female crab *P. palagicus* from Persian Gulf coasts located in South Iran.](image)

![Fig. 3—Mercury levels in tissues of male crab *P. palagicus* from Persian Gulf coasts located in South Iran.](image)

<table>
<thead>
<tr>
<th>Sampling stations</th>
<th>Abadan</th>
<th>Bahrekan</th>
<th>Boushehr</th>
<th>Khark</th>
<th>Bandar Abbas</th>
<th>Jask</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Season</strong></td>
<td><strong>Tissue</strong></td>
<td>****</td>
<td>****</td>
<td>****</td>
<td>****</td>
<td>****</td>
</tr>
<tr>
<td><strong>Summer</strong></td>
<td>Hepatopancreas</td>
<td>$1.69 \pm 0.55$</td>
<td>$4.70 \pm 0.80$</td>
<td>$1.05 \pm 0.33$</td>
<td>$2.60 \pm 0.39$</td>
<td>$1.60 \pm 0.44$</td>
</tr>
<tr>
<td></td>
<td>Muscle</td>
<td>$1.40 \pm 0.21$</td>
<td>$2.28 \pm 0.40$</td>
<td>$0.90 \pm 0.51$</td>
<td>$1.50 \pm 0.45$</td>
<td>$1.35 \pm 0.52$</td>
</tr>
<tr>
<td></td>
<td>Exoskeleton</td>
<td>$0.90 \pm 0.18$</td>
<td>$1.30 \pm 0.19$</td>
<td>$0.40 \pm 0.72$</td>
<td>$0.98 \pm 0.30$</td>
<td>$0.84 \pm 0.12$</td>
</tr>
<tr>
<td><strong>Winter</strong></td>
<td>Hepatopancreas</td>
<td>$1.44 \pm 0.15$</td>
<td>$4.39 \pm 0.05$</td>
<td>$0.95 \pm 0.15$</td>
<td>$2.31 \pm 0.20$</td>
<td>$1.44 \pm 0.22$</td>
</tr>
<tr>
<td></td>
<td>Muscle</td>
<td>$1.29 \pm 0.50$</td>
<td>$2.09 \pm 0.10$</td>
<td>$0.69 \pm 0.33$</td>
<td>$1.38 \pm 0.14$</td>
<td>$1.09 \pm 0.09$</td>
</tr>
<tr>
<td></td>
<td>Exoskeleton</td>
<td>$0.69 \pm 0.05$</td>
<td>$1.16 \pm 0.12$</td>
<td>$0.19 \pm 0.23$</td>
<td>$0.70 \pm 0.34$</td>
<td>$0.54 \pm 0.11$</td>
</tr>
</tbody>
</table>
There is a growing concern about the physiological and behavioral effects of environmental trace metals in human population and probably due to nearby petrochemical industries and a high amount of wastewaters containing Hg always dumped at this station. The results indicated that mean concentrations of Hg in the tissues of crab during Summer season was higher than mean concentrations of Hg during Winter season. There was no significant difference \((P<0.05)\) between the level of Hg during different seasons. In present study recorded that there was negligible differences in Hg levels between different seasons. The magnification order of Hg between tissues of crab was as follow: Hepatopancreas > Muscle > Exoskeleton (Figs 2, 3). The results showed that Hg mean concentrations in during two season and in different sexes and tissues of crab \(P. pelagicus\) in Bahrekan station were significantly higher \((P<0.05)\), and minimum mean concentration was in Boushehr station \((P>0.05)\), (Figs 6, 7).

Discussion

In present study, results showed that Hg concentration was highest in hepatopancreas, followed by muscle and exoskeleton. According to field and experimental studies, tissue distribution and accumulation of Hg in crabs varies widely depending on size, sex, growth stage, molting, migration, season of sampling, metal bioavailability, hydrodynamics of the environment, changes in tissue composition and reproductive cycle\(^{11}\). In our samples, we found significant correlations between Hg in sediments and tissues of crab \((P<0.05)\). Crabs in this study have very similar diets; they are all intermediate consumers which feed mainly on invertebrates for example: shrimp, bivalve and vegetation. Foraging grounds of these crabs are also somewhat different which leads to differences in prey size and ultimately Hg intake. Crabs also, spends more time in shallow waters and coastal and in terrestrial areas where anthropogenic Hg is less widely present. We therefore expected to see dissimilar levels of Hg in tissues of this specie.
Despite the fact that there were no significant differences in Hg levels between tissues of *P. pelagicus*, seasonal variation may affect metal concentration in body organism. This variation could result in internal biological cycle in organism or variation in bioavailability of metal in environment. Temperature, food availability and water could increase metal concentration in Summer than Winter, such this condition was happened during present study and Hg levels in different tissues showed higher in Summer season compared to Winter season. In other words, most levels of Hg in body organism is in the form methyl Hg which is soluble in fatty tissues, thus seasonal reproduction could be cause reduce mercury in Winter season. Similarly in the present study, less metal uptake was showed during Winter season. According to different studies the heavy metal concentrations in invertebrates showed higher in Winter and early Spring. It was revealed that algae and invertebrates all show similar seasonal patterns in metal concentrations it would seem likely that environmental factors (discharges to the estuary, pH, salinity, suspended matter, etc.) are having a greater overall influence on seasonality than biological factors (metabolism, reproduction, fluctuations in tissue weight, etc.). Seasonal variation in metal levels may be caused by such factors as land drainage to the marine environment availability of food, temperature and reproductive cycle and condition of the organism.

Although Hg levels marine organisms are important to know and from an ecotoxicological point of view, there is limited research findings related to Portunidae crab. For instance, in the region of the Persian Gulf, no results on Hg mean levels in Portunidae crab have been published, therefore it is not possible to compare the results directly. In relation to other species and other conditions, concentration of Hg in *P. pelagicus* in this study was compared with other studies around the world (Table 3). The mean concentration of Hg in Hepatopancreas of

**Table 3**—Comparison of Hg mean levels in tissues of various crab species from different parts of the world

<table>
<thead>
<tr>
<th>Species</th>
<th>Tissues</th>
<th>Hg (µg/g dry weight)</th>
<th>Location</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. pelagicus</em></td>
<td>Hepatopancreas</td>
<td>41.1 ± 13.43</td>
<td>Egypt</td>
<td>[25]</td>
</tr>
<tr>
<td><em>P. pelagicus</em></td>
<td>Gill</td>
<td>16.99 ± 5.06</td>
<td>Egypt</td>
<td>[25]</td>
</tr>
<tr>
<td><em>P. pelagicus</em></td>
<td>Muscle</td>
<td>0.068 ± 0.30</td>
<td>Egypt</td>
<td>[26]</td>
</tr>
<tr>
<td><em>P. pelagicus</em></td>
<td>Muscle</td>
<td>0.19 ± 1.80</td>
<td>Egypt</td>
<td>[26]</td>
</tr>
<tr>
<td><em>P. pelagicus</em></td>
<td>Muscle</td>
<td>0.19 ± 0.50</td>
<td>Philippines</td>
<td>[27]</td>
</tr>
<tr>
<td>Scylla serrate</td>
<td>Muscle</td>
<td>0.37 ± 0.90</td>
<td>Philippines</td>
<td>[27]</td>
</tr>
<tr>
<td>Mercenaria sp</td>
<td>Muscle</td>
<td>1.42 ± 0.30</td>
<td>Philippines</td>
<td>[27]</td>
</tr>
<tr>
<td><em>Cardisoma guahumi</em></td>
<td>Muscle</td>
<td>0.15 ± 1.44</td>
<td>Nigeria</td>
<td>[28]</td>
</tr>
<tr>
<td><em>Carcinus sp</em></td>
<td>Muscle</td>
<td>0.22 ± 0.03</td>
<td>Nigeria</td>
<td>[29]</td>
</tr>
<tr>
<td><em>P. pelagicus</em> study</td>
<td>Hepatopancreas</td>
<td>0.22 ± 0.60</td>
<td>Iran</td>
<td>present</td>
</tr>
<tr>
<td><em>P. pelagicus</em> study</td>
<td>Muscle</td>
<td>0.15 ± 0.63</td>
<td>Iran</td>
<td>present</td>
</tr>
<tr>
<td><em>P. pelagicus</em> study</td>
<td>Exoskeleton</td>
<td>0.08 ± 0.33</td>
<td>Iran</td>
<td>Present</td>
</tr>
</tbody>
</table>
P. pelagicus showed almost higher than other tissues during present study and other studies around the world. In present study, the concentration of Hg in tissues of P. pelagicus showed that higher than other conditions except in Lake Timsah, Egypt. However, in this study, concentration of Hg in tissues of P. pelagicus was compared WHO, FAO, UKMAFF and USFDA standard values. Concentration of Hg in Bahrekan and Khark stations showed higher than UKMAFF but low than other standards values. Meanwhile, concentration of Hg in other stations was lower than all standards values.

In present study recorded that there was negligible differences in Hg levels between sexes. We found that Hg levels were larger in tissues of female of the P. pelagicus than the males. There were no significant differences in Hg levels between sexes of P. pelagicus. Therefore the small difference that has been reported in Hg body burdens in male and female is consistent with our current data of the present study. Therefore, the negligible difference in Hg levels between sexes can be attributed to depuration in eggs, sexual dimorphism and niche partitioning of the forage base. Differences in Hg concentrations the species is likely to have resulted from metal bioavailability, hydrodynamics of the environment, changes in tissue composition, reproductive cycle different feeding mechanism, temperature, salinity, stations of collection and sources of pollution within Persian Gulf.

Very limited data on Hg exposure in Persian Gulf invertebrates are available. The data suggests that sediments have higher Hg levels than water and crab species. Information for evaluating the ecological risk implications of these isolated observations is lacking, and more information on Hg in sediments, water and in invertebrates is needed. To understand the impacts of Hg on biota and ecosystems, it is necessary to systematically collect data on a group of representative species (bioindicators) from a wide variety of ecosystems, stratified by presumed exposure to Hg. A systematic assessment of Hg should be carried out in conjunction with other bioaccumulative pollutants and other heavy metals in Persian Gulf animals.

Conclusion

The results of this study suggested that the accumulation of Hg in the aquatic organisms of the present study may be dependent on some factors such as metal bioavailability, hydrodynamics of the environment, stations of collection, temperature, salinity, crab sexes and sources of pollution. Hg accumulation in the different tissues and sediments increased as the exposure time increased. Magnification order of Hg in the sediments and tissues of P. pelagicus was as follow: sediments > tissues > water. It can be concluded from the present study that the tissues of crabs studied contain Hg less than the sediments and is safe for human consumption according to WHO criteria.

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